The CRUSHED STONE JOURNAL

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The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

J. R. BOYD, Editor

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THE
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A Method for Proportioning Concrete for Compressive Strength, Durability and Workability

By A. T. GOLDBECK[1] and
J. E. GRAY[2]

• Adequate but not extravagant compressive strength, workability and durability are the important qualities of most concrete. A remarkably simple method of proportioning which will produce the desired quality of concrete, irrespective of type or gradation of the aggregates, is here presented. It is founded on research, is easy to use and is dependable and practical.

THE proportioning of concrete is the determination of the quantities of water, cement and aggregates which, when mixed together and properly cured, will produce concrete having the desired workability, compressive strength and durability. While up to the present time a great many methods for proportioning concrete have been advocated, none has found general acceptance, because either all of the factors which affect concrete design have not been taken into consideration or the design method has been too complicated for practical use. The method of proportioning that is being proposed not only utilizes the important factors which affect the design of concrete mixes but it likewise makes their application easy and practical through the utilization of certain numerical design relationships which have been developed by extensive research. When proportioned by the present described method the resulting concrete will have the required compressive strength, workability and durability.

Although other properties of concrete such as fire resistance, impermeability, absorption, beam strength, shrinkage, etc., frequently are of importance, they are not treated in the present discussion. The property of impermeability is closely proportional to compressive strength. Fire resistance depends upon the thermal properties of the aggregates and is controlled largely by the coarse aggregate. The design of concrete for beam strength is quite a seperate subject, for beam strength and compressive strength do not always bear the same relationship one to the other.[3]

Fundamental Conceptions Involved in Concrete Proportioning

Solid Volume

It is important that certain fundamental conceptions used in the present method of concrete proportioning be thoroughly understood. The first of these is that of "Solid Volume". The solid volume in a given quantity, for illustration a cubic foot of aggregate, is the volume occupied by the pieces of aggregate alone and excluding the voids. The remaining portion is the volume of voids between the pieces of aggregate. Or conceived in another way, the solid volume of aggregate in a cubic foot of aggregate is the volume which the aggregate would occupy if it were melted into a solid piece without changing its density. The remaining volume, that of air in the cubic foot measure, would be equal to the volume of voids in the aggregate before it was melted into a solid mass.

The solid volume in a quantity of aggregate may readily be calculated. First, the "bulk specific grav-

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[3] Bulletin No. 7, National Crushed Stone Association ,entitled, "Investigations in the Proportioning of Concrete for Highways," by A. T. Goldbeck.

ity" must be known. This is simply the ratio of the dry weight of a substance to the weight of an equal volume of water.

(This statement, for simplicity, makes no mention of the different kinds of specific gravity or of the precautions necessary in testing. See Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate, A. S. T. M. Designation C127-39 and also Standard Method of Test for Specific Gravity and Absorption of Fine Aggregate, A. S. T. M. Designation C128-39.)

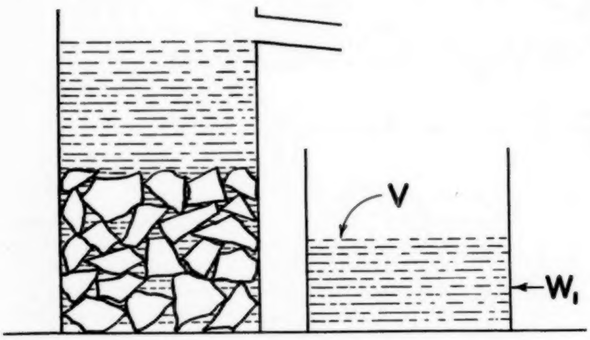

FIGURE 1

To illustrate the term "specific gravity" more clearly, imagine a quantity of stone introduced into a vessel, Fig. 1, previously filled with water up to the level of the overflow spout. When the stone, weighing W pounds is carefully immersed in the water, it displaces a volume of water, (V), equal to its own solid volume and weighing W_1 pounds.

The weight of water (W_1) displaced by the stone equals its volume in cubic feet (V) multiplied by the weight of a cubic foot of water (62.4 lb.) or $W_1 = V \times 62.4$ lb.

$$\text{Then specific gravity} = \frac{W}{W_1} = \frac{W}{V \times 62.4} \text{ or}$$

$$V = \frac{W}{\text{Sp.Gr.} \times 62.4} = \text{solid volume of stone (in cu. ft.) weighing W pounds.}$$

This is a fundamental conception which is largely used in concrete design.

Volume of Concrete is the Summation of the Solid Volumes of Its Components

The volume occupied by a concrete mixture is equal to the summation of the solid volumes occupied by its respective ingredients. This is exactly true except for the presence of a small amount of air in the mixture which generally may be ignored. Certain agents used during the grinding of some cements tend to rather greatly increase the air or gas space in the finished concrete and their effect would have to be taken into account in making calculations for volume of concrete. But this is a special problem which will not be considered at present.

To better understand the application of solid volume, consider the following practical problem:

Let it be assumed that someone not familiar with modern concrete specifications and design methods has specified that the concrete shall be in the proportions of 1:2:4 by loose volume. The ratio of water to cement by volume (W/C) also is specified to be 8 gal. per sack of cement. The materials are found to have the following characteristics:

	Weight per Cu. Ft. (lb.)	Bulk Specific Gravity
Cement	94 (one sack)	3.14
Sand	98.0 (loose volume)	2.63
Stone	95.6	2.73
Water	62.4 (7.5 gal. = 1 cu. ft.)	

Then a batch of concrete containing one sack of cement will produce a volume of concrete calculated as follows:

			Cu. Ft. of Solid Volume in a One-sack Batch
Cement	$\frac{94}{3.14 \times 62.4}$	=	0.48 cu. ft.
Sand	$\frac{2 \times 98}{2.63 \times 62.4}$	=	1.20 cu. ft.
Stone	$\frac{4 \times 95.6}{2.73 \times 62.4}$	=	2.25 cu. ft.
Water (W/C)	$= \frac{8}{7.5}$	=	1.07 cu. ft.
		Total	5.00 cu. ft. of concrete per sack of cement.

Quantities Required per Cu. Yd. of Concrete

Cement per cu. yd.	=	$\frac{27}{5.00}$	=	5.4 sacks
Sand per cu. yd.	=	$2 \times 5.4 \times 98$	=	1058 pounds
Stone per cu. yd.	=	$4 \times 5.4 \times 95.6$	=	2066 pounds
Water per cu. yd.	=	8×5.4	=	43.2 gallons

The percentage of sand by solid volume in the total fine and coarse aggregates equals $\frac{1.20}{1.20 + 2.25}$ equals 34.9 which generally is too little sand for proper workability unless the coarse aggregate is large in size. This example illustrates why unworkable concrete results with the old-fashioned method of arbitrary proportioning by volume. Most decidedly is this arbitrary method of concrete proportioning not advocated. It has no basis of fact to support it and its use leads to unworkable concrete, the attempted cure for which is to add an excess of mixing water.

Water-Cement Ratio Compressive Strength Relationship

In 1918, there appeared in Bulletin 1 of the Structural Materials Research Laboratory, Lewis Institute, Chicago, entitled, "Design of Concrete Mix-

tures" by Duff A. Abrams, a statement of the important relationship between the compressive strength of concrete and the water-cement ratio.

Prof. Abrams stated as a result of extensive tests that, "*With given concrete materials and conditions of test* the quantity of mixing water used determines the strength of the concrete as long as the mix is of a workable consistency." (Note: The italics are ours.)

Unfortunately, very few engineers have realized what Prof. Abrams evidently knew about the limitations of this relationship. They have attempted to apply a single average water-cement compressive strength relationship to all cements and to all aggregates, apparently not realizing that different cements, different aggregate characteristics and other variables also control the compressive strength of concrete to an appreciable extent.

The fact is that the water-cement compressive strength relationship is not a single relationship, but is a family of relationships. These various relationships, expressed graphically are sometimes separated to an important extent although paralleling one another. They differ because different cements frequently *do* have different strengths and also because both the fine and the coarse aggregates have a range in surface texture, in absorption, shape and chemical characteristics which may affect the compressive strength of the concrete in addition to their effect on the water-cement ratio. Briefly, then, there is only a general relationship between the water-cement ratio and the compressive strength and it is very important to note that there are individual and specific water-cement ratio compressive strength relationships for specific materials which can and frequently do depart from the average water-cement ratio compressive strength relationship. The higher strengths frequently are obtained with the higher water-cement ratios because of the beneficial effects of the aggregates.

Water-Cement Ratio Affects Durability

The more severe the exposure conditions the less should be the water-cement ratio, but this statement does not mean that small differences in water, such as might be required because of differences in aggregate characteristics will surely cause distintegration in one case and durability in another under service conditions. As a matter of fact, it frequently happens that the durability of two concretes is the reverse of what would be expected from the water-cement ratio relationships, due probably to the further influence of differences between thermal coefficients, surface texture, shape and other characteristics of aggregates. Only in a general way is durability controlled by water-cement ratio. When concrete is subjected to severe exposure conditions, it is well to avoid excessively high water-cement ratios no matter what aggregates are used.

The method of concrete proportioning hereinafter described recognizes the water-cement ratio compressive strength and durability relationships; it utilizes these relationships in a practical manner which is simple to apply.

Effect of Amount of Coarse Aggregate in Concrete on Workability

Obviously, the amount of coarse aggregate in a concrete mixture has a most important influence on its workability. If the pieces of coarse aggregate were located as closely together in a concrete mixture as they exist when in a stockpile, the concrete would have no plasticity or workability for the coarse aggregate would be so interlocked that the pieces could not turn or move with respect to one another. When the pieces are separated by mortar they have opportunity for motion. Sufficient separation is accomplished by the use of sufficient mortar in the mixture and, in general, the greater the volume of mortar, the more plastic or workable will be the concrete. Obviously, however, since sand has great surface area, the greater the quantity of sand above that required for workability, the greater will be the amount of water required for a given consistency and therefore just enough sand to accomplish the required workability should be used. One of the fundamental and highly important conceptions, then, in the proportioning of concrete for plasticity or workability is that the necessary film thickness of mortar must exist around the coarse aggregate pieces to keep them sufficiently separated so that they might move relative to one another. This is accomplished in a practical manner by using just the right volume of dry, rodded coarse aggregate in a unit volume of concrete.

Before proceeding it is important to have the following definitions clearly in mind:

Let b = the solid volume of coarse aggregate in a unit volume of concrete.

Let b_0 = the solid volume of coarse aggregate in a unit volume of dry, rodded coarse aggregate.

Then b/b_0 is the dry, rodded volume of coarse aggregate in a unit volume of concrete. (See Appendix 1 for explanation.)

TABLE I

Dry, Rodded Volume of Coarse Aggregate (Any Type) per Unit Volume of Concrete (b/b_0)

Size of Coarse Aggregate, Square Opening Laboratory Sieves	Fine Sand		Medium Sand			Coarse Sand		
	Fineness Modulus of Sand							
	2.40	2.50	2.60	2.70	2.80	2.90	3.00	3.10
	Values for b/b_0							
#4 to ¾ in.	.71	.70	.69	.68	.67	.66	.65	.64
#4 to 1 in.	.72	.71	.70	.69	.68	.67	.66	.65
#4 to 1½ in.	.74	.73	.72	.71	.70	.69	.68	.67
#4 to 2 in.	.76	.75	.74	.73	.72	.71	.70	.69
#4 to 2½ in.	.78	.77	.76	.75	.74	.73	.72	.71

b/b_0 = dry, rodded volume of coarse aggregate per unit volume of concrete.
b_0 = solid volume of coarse aggregate per unit volume of coarse aggregate.
b = solid volume of coarse aggregate per unit volume of concrete.

Note: For concrete pavements or other work in which there should be less mortar than required in the usual structural concrete, increase tabulated values of b/b_0 approximately 10%.
For concrete especially designed to be compacted by internal vibration under very rigid inspection, increase tabulated values of b/b_0 approximately 15%.

TABLE II

Cement Factors (Sacks of Cement per Cu. Yd. of Concrete) Required for 28-Day Compressive Strengths Listed

Size of Coarse Aggregate			#4 to ¾ in.		#4 to 1 in.		#4 to 1½ in.		#4 to 2 in.		#4 to 2½ in.	
Slump (in.)			3	6	3	6	3	6	3	6	3	6
Water, gal. per Cu. Yd. of Concrete	Angular Coarse Aggregate		40	42	38	40	36	38	35	37	34	36
	Rounded Coarse Aggregate		36	38	34.5	36.5	33	35	32	34	31	33
28 Day Compressive Strength	2000	Sacks of Cement per cu. yd. of Concrete	4.6	4.9	4.4	4.6	4.2	4.4	4.1	4.3	4.0	4.2
	2500		5.0	5.3	4.8	5.0	4.5	4.8	4.4	4.6	4.3	4.5
	3000		5.5	5.8	5.2	5.5	4.9	5.2	4.8	5.1	4.7	4.9
	3500		6.0	6.3	5.7	6.0	5.4	5.7	5.2	5.5	5.1	5.4
	4000		6.5	6.8	6.1	6.5	5.8	6.1	5.7	6.0	5.5	5.8
	4500		7.1	7.4	6.7	7.1	6.3	6.7	6.2	6.5	6.0	6.3
	5000		7.7	8.1	7.3	7.7	6.9	7.3	6.8	7.1	6.5	6.9

Note: The 28-day compressive strengths shown are the minimum values to be expected and should be used for design purposes. Laboratory specimens cured under ideal conditions will generally have higher strengths.

By means of tests on typical materials, the correct values for b/b_0 have been determined. This work has been done in the laboratory of the National Crushed Stone Association and elsewhere and, as a result, the values for b/b_0, given in Table I, have been determined as the desirable volumes of

dry, rodded coarse aggregate to use per cubic foot of concrete. These values vary with the maximum size of coarse aggregate and with the gradation of the sand, but, for practical purposes of design they may be taken as identical for different types of coarse aggregate.

Fineness modulus is used as an index of the sand gradation and, as usual, it is defined as the sum divided by 100 of the total percentages of sand retained on the following sieves:

Tyler Series	Equivalent Sieves U.S. Standard Series
No. 100	No. 100
48	50
28	30
14	16
8	8
4	4
3/8 in.	3/8 in.

The values for b/b_0 (i. e. dry, rodded volume of coarse aggregate in a unit volume of concrete) given in Table I are to be used in proportioning concrete mixtures containing any kind of standard coarse aggregate.

When the values for b/b_0 given in Table I are used in the manner about to be explained, practically all differences in coarse aggregates which will affect the proportions are allowed for automatically. That fact makes the present method extremely simple to use. Thus, stone generally has a greater percentage of voids than gravel, but the present method of proportioning results in just enough extra mortar to fill the extra voids. If coarse aggregates are graded differently, thus creating different percentages of voids, the method allows for that. If aggregates have different specific gravities, that difference is taken care of also. It seems difficult to conceive of a more practical method for taking into account the many differences in coarse aggregates and gradation of fine aggregates to the end that concretes of essentially equal strength, workability and durability will result.

Determination of Total Water and Cement Factor

Only by tests on concrete made with the particular materials to be used can the most accurate determination be made as to the necessary proportions. All that any concrete proportioning method can do in the absence of concrete tests with specific materials is to furnish a rather accurate prediction as to the most probable proportions for producing the required workability, strength and durability. A very necessary part of the preliminary work leading to the present method was the performance of numerous concrete tests on typical concrete materials. These tests have resulted in the setting up of relationships (See Table II) between 28-day compressive strength, cement factor, slump and total water per cubic yard of concrete.

For the same slump or consistency, the same cement factor is used with all standard types[1] of coarse aggregates of the same size to produce a required compressive strength. This is a safe and practical way of obtaining concrete having a required strength. Different coarse aggregates of the same size will produce only immaterial variations in strength when the same cement factor and consistency are used. This is not true of beam strength, however.

Explanation of Method of Proportioning

The foregoing principles and tabulated relationships which have been established by laboratory tests may be utilized for the practical proportioning of workable concrete having any desired strength and consistency. Briefly, the method involves the following steps:

1. Use of Tabulated Test Values

It utilizes laboratory tests on typical concrete materials which have:

(a) Established the volume of coarse aggregate, measured dry and rodded, required per unit volume of concrete so that when separated by the mortar, the concrete will be properly workable. (See Table I, values for b/b_0).

(b) Established the cement factor and total water per cubic yard of concrete, for a given strength, slump, size and type of coarse aggregate. (See Table II.)

2. Tests on the Particular Materials to be Used

The values in Tables I and II are used in conjunction with the following test values, determined for the particular materials to be used.

*a. Bulk specific gravity of the coarse aggregate (A. S. T. M. C127-39)

*b. Bulk specific gravity of the fine aggregate (A. S. T. M. C128-39)

[1] In general, by standard types is meant crushed stone, gravel and air-cooled blast furnace slag of acceptable weight and physical properties.

* These values are generally known for commercial aggregates.

c. Dry, rodded weight of coarse aggregate (A. S. T. M. C29-39)

d. Gradation and Fineness Modulus of sand and gradation of coarse aggregate (A. S. T. M. C136-39)

e. Assume specific gravity of cement equals 3.14 or determine the specific gravity.

3. Preliminary Calculations and Determinations

a. Calculate solid weights per cubic foot of the cement, of the fine and of the coarse aggregates. (bulk specific gravity times 62.4 lb.)

b. Knowing the size of coarse aggregate and fineness modulus of sand, determine from Table I the proper value of b/b_o.

c. Calculate the solid volume of coarse aggregate per cubic foot of dry, rodded coarse aggregate (b_o).

$$b_o = \frac{\text{dry, rodded weight per cu. ft.}}{\text{solid weight per cu. ft.}}$$

d. Calculate $b = b/b_o \times b_o$

e. Knowing the kind and size of coarse aggregate, the 28-day strength and slump of concrete desired, determine from Table II, the cement factor, and the total water in gallons per cubic yard.

4. Final Calculations of Weights of Materials Required per Cu. Yd. of Concrete

a. Sum up the solid volumes of cement, coarse aggregate and water.

b. Twenty seven cubic feet minus the solid volumes of cement, coarse aggregate and water equals solid volume of sand in a cubic yard of concrete.

c. Convert solid volumes of cement, sand and coarse aggregates to weights using values calculated under No. 3a above.

Practical Example of Method of Proportioning

Example. It is required to determine the proportions of crushed stone concrete to have 3500 lb. per sq. in. compressive strength at 28 days; 6 in. slump.

Preliminary Determinations

Stone

Size No. 4 to 1½ in.
Specific gravity = 2.72
Solid weight = 2.72 × 62.4 = 170 lb. per cu. ft.
Dry rodded weight = 101.3 lb. per cu. ft.

$b_o = \frac{101.3}{170} = 0.596$ cu. ft. of solid stone per cu. ft. of dry, rodded stone.

Sand

Specific gravity = 2.63

Solid weight = 2.63 × 62.4 = 164 lb. per cu. ft.

Gradation	
Sieves*	Total Percentage Retained
⅜ in.	0
No. 4	1
8	12
16	27
30	48
50	72
100	97

Fineness Modulus 2.57

*Above sieves are the U.S. Standard equivalents of the Tyler sieves.

Cement

Specific gravity = 3.14
Weight per cu. ft. (one sack) = 94 lb.
Solid weight = 3.14 × 62.4 = 196 lb. per cu. ft.
Solid volume per sack $= \frac{94}{196} = 0.48$ cu. ft.

Calculation of Proportions from Above Data

From Table I, for sand having a F.M. of 2.57 and stone of No. 4 to 1½ in. size, $b/b_o = 0.72$ and therefore:
$b = b/b_o \times b_o = 0.596 \times .72 = .429$ cu. ft.
(equals solid volume of stone in a cubic foot of concrete)

From Table II, Cement = 5.7 sacks
Water = 38 gal. per cu. yd.

		Solid Volumes of Constituent Materials (cu. ft. per cu. yd. of concrete)	Quantities per Cu. Yd.
Cement = 5.7 sacks × 0.48	=	2.74 cu. ft.	= 5.7 sacks
Stone = 0.429 × 27	=	11.58 cu. ft. × 170 lb.	=1969 lb.
Water = 38 gal. = $\frac{38}{7.5}$	=	5.07 cu. ft.	= 38 gal.
Total		19.39 cu. ft. = solid volume of cement, stone and water in a cu. yd. of concrete.	
Sand = 27 − 19.39	=	7.61 cu. ft. × 164	= 1248 lb.

Percent sand by solid volume of total aggregate $\frac{7.61}{7.61 + 11.58} = 39.6\%$

The proportions thus obtained will give, very closely, the kind of concrete desired. The strength values tabulated in Table II are the minimum to be expected and the actual values obtained may range somewhat above these tabulated figures.

Please note that the weights of fine and coarse aggregates are for the aggregates in a dry condition. If free water exists on the aggregates, its percentage must be obtained for each aggregate and the weights of aggregates per cubic yard of concrete increased. But in that case a corresponding decrease must be made in the weight of mixing water used.

TABLE III

Properties of Concrete Having Suitable Strength and Durability for Different Classes of Work

Slump in.	Size of Coarse Aggregate	Expected 28-day Strength	Typical Classes of Work for Which Recommended
2–3	#4 to 2	3000	Heavy sections, such as dams, foundations, heavy walls.
3–6	#4 to 1 #4 to ¾	2500	Unexposed reinforced concrete beams and slabs.
2–3	#4 to 2	3500	Submerged concrete.
2–3	#4 to 2	4000	Structures under moderate exposure, concrete subject to intermittent wetting.
2–5	#4 to 1 #4 to 1½	3500 4000	Foundation walls, reservoirs, sewers, columns of buildings.
2–4	#4 to 1½	4500	Severe exposure at water-line.
3–6	#4 to ¾	4500	Very severe exposure of thin reinforced sections.
3–6	#4 to 2	5000	Concrete for depositing under water.

NOTE: Use cement factors given in Table II.

If the aggregates are dry, they will absorb water from the mixture and it is usual to determine the amount of absorption by the aggregates in 30 minutes and increase the mixing water by the weight of water which will be absorbed by the aggregates. A numerical example of these corrections for water is given later. (See page 10.)

Possibly slight adjustments in the field proportions will have to be made after the work is started, but if the preliminary determinations and calculations have been made correctly, these adjustments will be very small in amount.

What Concretes are Suitable for Different Classes of Work?

In Table III are given the essential characteristics of typical concretes suitable for different classes of work.

Suggested Specification for Concrete Proportions

A specification for concrete proportions may be written to best utilize the present method of proportioning. It permits any standard type of aggregate to be used and requires no information regarding the aggregates at the time the specification is written.

Specification for Concrete Proportions

All concrete shall be proportioned as indicated in the following table.

Class of Concrete	Estimated 28-day Compressive Strength	Cement Factor Sacks of Cement (94 lb.) per cu. yd.	Coarse Aggregate Size Range Square Openings	Maximum Slump (inches)

The concrete shall be proportioned by weight to contain that particular dry, rodded volume of coarse aggregate per unit volume of concrete (b/b_0) designated in Table I for the size of coarse aggregate and fineness modulus of the sand to be used on the work.

Upon written permission from the Engineer minor changes in the concrete proportions may be made to obtain the desired strength, consistency or workability. Should a change in cement factor be ordered to attain the estimated strength, due allowance shall be made in the contract price equal to the actual difference in cost to the contractor of the aggregates and cement.

Include Table I from page 6 as a part of this specification.

It is intended that the architect or engineer will insert the required values in the above specification.

Table I is a part of the specification. Table II (from page 6) should be appended for convenience in proportioning the concrete.

Let it be emphasized that nothing need be known about the concrete materials when writing such a specification. Their characteristics need not be known until it finally is necessary to determine the concrete proportions. At that time the size (to determine conformity with the specification), type, dry, rodded weight per cubic foot and bulk specific gravity of the coarse aggregate and the specific gravity and gradation of the sand must be known to properly proportion the concrete. *Generally, the specific gravity values are already known, leaving only the dry-rodded weight of coarse aggregate and gradations of the aggregates to be determined.*

Illustration of Use of Above Specification

It is desired to specify concrete suitable for thin reinforced beams and slabs not exposed to the weather. The coarse aggregate should be No. 4 to ¾ in. in size for this class of work. The other values (from Table II) to be inserted in the above specifications would be 2500 lb. per sq. in. at 28 days, 6 in. slump and 5.3 sacks per cu. yd. The class of concrete can be given an appropriate designating number or letter.

Assuming the use of crushed stone as the coarse aggregate, the following are calculations which will be necessary to determine the proportions in the above illustration.

Preliminary Tests and Calculations

Characteristics of aggregates and cement to be used:

Sand

Specific gravity = 2.65
Solid weight of sand = 2.65 × 62.4 = 165 lb.
Fineness modulus of sand 2.90

Stone

Specific gravity = 2.60
Solid weight of stone = 2.60 × 62.4 = 162 lb.
Dry, rodded weight of stone = 90 lb.

$$b_\circ = \frac{90}{162} = 0.556$$

Cement

Specific gravity = 3.14
Weight per cu. ft. (1 sack) = 94 lb.
Solid weight = 3.14 × 62.4 = 196 lb.

$$\text{Solid volume} = \frac{94}{196} = 0.48 \text{ cu. ft.}$$

Calculation of Proportions

Cement, from Table II, 5.3 sacks per cu. yd.
Water, from Table II, 42 gal. per cu. yd.
$b/b_\circ$ from Table I, for F.M. of 2.90, and No. 4 to ¾ in. stone = 0.66
$b_\circ = 0.556$, so $b = b_\circ \times b/b_\circ = 0.556 \times 0.66 = 0.367$

		Cu. Ft. Solid Volume per Cu. Yd.				Quantities per Cu. Yd. of Concrete
Cement,	5.3 × 0.48 =	2.54	×	196	=	498 lb.
Stone,	0.367 × 27 =	9.91	×	162	=	1605 lb.
Water,	42/7.5 =	5.60	×	7.5	=	42 gal.
	Total	18.05				
Sand,	27 − 18.05 =	8.95	×	165	=	1477 lb.

Corrections for Moisture in Aggregates

The above are dry weights of sand and stone and therefore corrections in the proportions of sand, stone and water must be made, depending on the moisture conditions of the aggregates on the job.

1. Both sand and coarse aggregate are shipped dry

If the sand has an absorption at the end of 30 minutes in water of 0.5%, add 0.5% × 1477 lb. or 7.4 lb. to the weight of the mixing water which equals

$$\frac{7.4}{8.33 \text{ lb.}} = 0.9 \text{ gal.}$$

If the stone has an absorption of 0.3% at the end of 30 minutes, add 0.3 × 1605 lb. or 5 lb. to weight of the mixing water, or 0.6 gal. The total increase in mixing water is then 0.9 + 0.6 = 1.5 gal. per cu. yd. of concrete.

2. Both sand and coarse aggregate are wet

If the above materials are both wet and have 3% of free water on the sand and 1% on the stone, and, in addition, 1% absorbed water in the sand and 0.5% in the stone, add 4.0% × 1477 or 59 lb. to 1477 = 1536 lb. of wet sand.

Due to 3% free water on the sand, the weight of mixing water must be decreased by 3% × 1477 or 44 lb.

Due to 1% free water on the stone, in addition to its absorbed water of 0.5%, add 1.5% × 1605 lb. or 24 lb. to the weight of stone, making the total weight of stone to be 1605 + 24 or 1629 lb.

Due to free water on the stone of 1%, the mixing water must be decreased by 1% × 1605 or 16 lb.

The total gallons per cu. yd. of mixing water, then,

$$= 42 - \frac{(44 + 16)}{8.33} = 42 - 7.2 = 34.8 \text{ gal.}$$

(*Continued on page 20*)

The Transportation Situation[1]

By JOSEPH B. EASTMAN
Director of the Office of Defense Transportation, Washington, D. C.

• A crisis is undoubtedly approaching in the field of transportation. To meet it successfully will require the fullest possible cooperation on the part of carriers and shippers alike. The following observations by Mr. Eastman should helpfully contribute to a better understanding of the situation.

SINCE appointment to my present position, I have made several public talks, like the one I am now making. If, by any chance, you may have heard or read any of those talks, you will not find much that is new in this one. My reason for being here today is because the Atlantic States Shippers Advisory Board, like all the other Regional Shippers Advisory Boards, is an organization which represents both carriers and shippers and has for its object the promotion of adequate and efficient transportation service. A tremendous responsibility rests upon the carriers and the shippers of the country, because, in contrast with what happened at the time of the last World War, the railroads have been left in the hands of their private owners and are still privately managed. Up to date in the present emergency, which really began as far back as 1939, they have done splendid work; but they have a very hard road ahead, and they will need all the help they can get. No one can give them better and more effective help than the shippers, and I know that the shippers pray that the carriers will make good. If, by talks such as the one I am now giving, I can in any way contribute to that cause and spur the carriers and the shippers on to pinnacles of effort, time could not be better spent.

Let me give you a picture of the present situation. We are at war with half the world. Without transportation we could not fight at all. In these days there is nothing which enters into war, from troops to bullets, which is not dependent absolutely on transportation. It is the one thing which is not only indispensable but all-pervasive, whether it be, for example, the transportation of iron ore from the mines, the transportation of wheat from the farms, the transportation of tank or airplane parts, the transportation of troops and their armaments, or the transportation of workers to and from the war production plants. Why, in the organization of the War Production Board, transportation should be classed with "civilian supplies" I have been quite unable to comprehend. So long as the machinery of transportation is clicking smoothly, it is easy to overlook the vital part which it plays in the war effort. Once, however, it begins to skip and falter at any point, as it did not long ago at this very port of Philadelphia, we hear about it from every war quarter.

It is a pleasure to be able to say, as I have already indicated, that thus far no industry has functioned more admirably in the war effort than the transportation industry. One of the reasons is that the lessons of the last World War were heeded, and particularly the lesson that cars must be kept in circulation and not used for storage purposes. Another reason is that the carriers have had the support and effective cooperation of the shippers and such organizations as this Atlantic States Shippers Advisory Board. It was because of this close partnership between the carriers, including their employees, and the shippers that the railroads last year set an all-time record for ton-miles carried with about one-third less cars than they had in 1929.

However, I did not come here to pat you on the back but to point out the dangers which lie ahead. I do not wish to be an alarmist, but let us take account of stock. Our country is rapidly accelerating to a supreme effort in production such as has never been seen before, any time anywhere. The program includes not only enormous stocks of air planes, tanks, guns, trucks and all the other implements of war, but also the huge flotillas necessary to move the troops and their armaments, as well as supplies of all sorts for our allies, across the seven seas to the theaters of action. Notwithstanding the record figures of 1941, there will be much more traffic to move in 1942 and still more in 1943. Not only that, but the railroads have lost the help of the intercoastal and most of the coastwise shipping. A great tonnage has been diverted from water to rail. Most of it is long-haul traffic, and the end is not yet in sight. Not so long ago, tank cars were almost a drug on the market. In November of last year, they were carrying about 70,000 barrels a day of oil to the Eastern Seaboard. Now they are carrying more than 500,000 barrels, with a heavy demand for more. This is merely

[1] Before the Atlantic States Shippers Advisory Board, in Philadelphia, Pa., April 9, 1942.

an illustration. All this has imposed a great strain on cars and an even greater strain on motive power. Ton-miles are increasing at double the rate for car loadings. On top of this is the fact that there is a heavy and a continually increasing movement of troops and their impedimenta and of furloughed men, with a new and abnormal trend of traffic over the long routes to the Pacific Coast area.

Looking still further into the future, we see impending the results of the rubber shortage. While the railroads, as I have said, carried more ton-miles than ever before in 1941, the trucks carried at least as much as 18 per cent additional ton-miles, and much of it was the kind of freight that it is most difficult for the railroads to carry efficiently and economically. Moreover, as you know, the railroads have now geared the truck into their own operations. It is doing for them all manner of terminal and way-station work which can be done better in that way than by rail. If, because of the rubber shortage, the railroads are ever called upon to move the traffic which the trucks now carry, and to do the work which the trucks now do, the load which fell upon them from the diversion of water-borne freight will seem of minor consequence in comparison.

When it comes to passenger traffic, the rubber-tired highway vehicle has for a long time been a far more important factor than the railroads in the movement of the population. With present equipment the railroads could not begin to take its place, even if they were not faced with the paramount duty of being on call at all times to handle the continually increasing troop movements. To add to the gravity of the situation, many of the great new war production plants have been located in main reliance on the private automobile as the means of carrying the workers to and from their work.

You may say that the answer to all this is to build more cars and locomotives, more barges and more pipe lines, and in whatever amounts may be necessary. That would be an answer, and it is one of my principal duties to do everything I can to see to it that the carriers get the materials, equipment and facilities that they need. But the decision on that point lies, not with me, but with the War Production Board. Bear in mind that there is only a limited stock of steel and the other critical war materials, and of furnaces, manufacturing plants and machine tools. The demands of the war production program and the ocean shipping program upon that limited stock are tremendous, and the War Production Board has the extraordinarily difficult task of allocating what is available as between those demands and the demands of transportation and civilian supplies. There is not enough to go around. I fear that the Board, in view of the enormous programs for armaments and ocean shipping, may make the mistake of taking a greater chance with domestic transportation than may be wise. Certainly, you may be sure that the carriers will not have an abundance of locomotives and cars. They will need before long to bring every ounce of their reserve power into play and to make the maximum possible use of what they have got.

The carriers will need the same sort of creative imagination, versatility and ability to improvise which characterizes modern warfare in the field of combat. They will need to operate much more nearly as a unit than in normal times, to make cooperation the watchword instead of competition, to share not only their freight cars but their passenger equipment and locomotives, and to pool their resources in many instances. I am glad to say that the Department of Justice has recognized the need for this and has worked out with my Office plans whereby such unity of action can lawfully be brought about. As you know, some such plans are provided for in my General Order No. 1, the object of which is to release for other uses a large number of the cars which are now used in the movement of less-than-carload freight. This traffic has accounted for 1½ percent of the total tonnage, but has been using 20 percent of the car supply. Some of you, I know, are doubtful of that order, and fear it may not work. Time will tell. We believe it will work, and certainly it is clear that it is directed to an outstanding case of inefficient use of equipment which in these times ought not to be tolerated if there is any possible way of avoiding it.

Reduced to simple terms, the way to get the maximum use out of the freight cars is, first, to load them to capacity and, second, to keep them rolling, as fast as possible and by reasonably direct routes. The figures show that the cars spend more than five times as much time in terminals as they do on the road. For a considerable part of that terminal time the carriers are responsible. A lot of that part is, I know, unavoidable, but this may not be true of all of it, and with the carriers we aim to explore those operations thoroughly. However, the shippers are also responsible for a very large part of the terminal time. Every hour they can save in loading and unloading cars increases by that much the ability of the railroads to serve. The individual hours may seem insignificant, but there are millions of shippers, and the

sum total result is equivalent to the building of several thousand new cars. The Regional Advisory Boards, the Car Service Division of the Association of American Railroads, the Bureau of Service of the Interstate Commerce Commission, and many commercial organizations have been doing fine work in promoting quick loading and unloading of the cars, but they have got to do more. There is still room for improvement, and this is true in even greater degree of the loading of the cars. That, I think, is the weakest point right now in shipper performance. The time has gone by for the luxury of commercial minimums and the half-loaded cars, of which there still are many. We are at war, and the worst war this country has ever fought. It is not too much to ask shippers to do their bit by loading these cars to capacity, even if it means not only inconvenience but sacrifice. We hope to give them some help in the form of tariff changes.

Another thing of great benefit that the shippers can do is to spread the load as much as possible over the year. The railroads have had to provide equipment for a peak in traffic demands which, for the country as a whole, normally comes each year in the month of October. Without that peak, they could have got along with less. If the peak could be leveled off, that in itself would add materially to railroad capacity to serve. There are indications that the peak is becoming a plateau, but perhaps it can be reduced to something like a plain. Pennsylvania is a State which produces a vast amount of coal, both bituminous and anthracite. If the shippers and consumers of this coal want to help win the war, they will ship and buy and stock all the coal possible in the spring and summer months. The coal shipping campaigns which were carried on last year in those months were of the utmost benefit in enabling the railroads to get by the October peak without difficulty. This year those campaigns must be intensified and extended to all other commodities which can be carried in stock.

Of course, it will be necessary, also, to make the best possible use of all of the other forms of transportation, as well as the railroads. So far as freight is concerned, that means the water carriers, the trucks, and the pipe lines. The intercoastal ships have gone, and many of the coastwise ships. The barges on the inland and coastal waterways remain. They now have some spare capacity. For example, the barges on the Mississippi River System can carry considerably more traffic southbound. The Waterway service can also be expanded, if new towboats and barges can be built. The pipe lines can do little more than they are now doing, in the absence of new construction or reconstruction. Plans of this character are under way or in contemplation which will be of help, but they will not help the railroads, because the demands upon them for the movement of oil will continue to be in excess of their tank-car capacity.

So far as the trucks are concerned, the shortage of rubber and other critical materials stands in the way of any new supply. The service which they can provide is not an expanding but a diminishing quantity. The truck problem—and it stands at the very peak of importance—is to keep the existing supply in service as long as possible and to avoid every wasteful or unnecessary use. That means, first and foremost, the protection of the tires against all avoidable wear and tear, similar protection of the vehicles and general application or the best possible methods of maintenance. To those ends we are working in close cooperation with the industry and with other agencies of both the Federal and the State governments. But we cannot stop there, for it is just as essential to eliminate all wasteful use of both vehicles and tires.

If I were to give you the impression that this is something that can easily be done, I would be misleading you sorely. The trucks are not owned, like the railroads, by a comparatively few and generally large companies. They have thousands and even millions of owners. Through an extensive field force which we are creating and with the help of the State authorities and of carrier and shipper organizations, and where necessary by appropriate directives, we plan to eliminate many empty hauls, much underloading, wasteful transfers of lading and unnecessary multiplications of movement in both road-haul and pick-up and delivery service. We also plan to shift trucks from places of excess supply to locations where they are needed, but always with regard for the just rights of their owners.

Speaking very broadly, truck service is more efficient and economical for short hauls than railroad service, which in turn is more economical for long hauls. This being so, there are those who propose that definite limits be set to the hauls which each of these types of carriers may be permitted to perform. The fact is that this broad rule has many exceptions, and disadvantages in cost are often outweighed by advantages in service. Every day, for example, the Army and Navy and the war production plants are calling upon trucks for long-haul service where quick and certain service is necessary. It is also true that many trucks which operate for long

distances carry much more short-haul than long-haul freight. It is not a situation where arbitrary standards can with any wisdom be applied. There are, however, many clear cases which demand action. For example, tank trucks should most certainly be used in place of tank cars for short hauls of oil and other liquids, and such substitution, I am glad to say, is now going on all over the country.

In this connection, if I may divert for a moment from freight to passenger service, let me say a word about the bus. There are those who conceive of the intercity bus as merely an unnecessary and wasteful duplication of railroad passenger service, and urge that such buses be taken off the road at once and used in carrying workers to and from the great new war production plants. It is true that there is waste in bus service, just as there is in truck service, and I believe that with the elimination of this waste it may be possible to release a considerable number of intercity buses for war plant use. But those who regard the service which they now provide as a mere duplication of railroad service are not well informed. The fact is that the distribution of our population and railroad passenger service itself have changed radically since the highway automotive vehicle came to be, what it now is, the predominant factor in the transportation of persons. There are only about 18,000 buses in intercity service, and of these not more than 6,000 are in what may be termed long-haul service. They perform a service and meet needs which are very different from those which the railroads are now equipped to perform or meet through their passenger trains. This is attested by the fact that the railroads now operate many intercity buses themselves and have financial interests in companies which operate many others. The bus service is in large part a local service, often at points not served by the railroads, which is greatly needed by our population, and in addition these intercity buses participate in troop movements, haul a very large volume of soldiers, sailors, and defense workers, and are used almost exclusively for the movement of selectees from their homes to the induction centers. It would be a gross error to wipe them out, although, as I have already stated, there is considerable present waste in their operations which can and must be eliminated.

Coming back to freight service, with which you are chiefly concerned, I hope that I have not painted too gloomy a picture, and I do not wish you to think that I am prophesying any immediate or near car shortage. What I am concerned about is the somewhat more distant, but not remote, future; and about that I am very greatly concerned. Since October 1, 1939, railroad traffic has, as you know, very greatly increased, and there is not a forecaster that I know of that does not predict a continual increase for so long as the war continues, entirely apart from any effect of the rubber shortage. In the same period, since October 1, 1939, the number of freight cars which the railroads own has increased by only 74,147, or less than 5 percent, and there has been an actual decrease in the number of locomotives, although the total tractive effort has increased. The War Production Board now proposes to permit the construction in the remaining months of 1942, in addition to the completion of equipment already authorized but still under construction, of 250 steam locomotives, 50 diesel-electrics, and 18,000 freight cars with wood substituted for steel to the extent practicable.

Notwithstanding the meager additions to equipment which have been made since 1939 in the face of a tremendous increase in traffic, the railroads have met all needs, with a few minor and temporary exceptions, adequately and efficiently. Every one must concede that they have done an outstanding piece of work. I know that, regardless of how many new cars and locomotives they are permitted to have, they will do everything in their power to continue their excellent performance, drawing upon their reserve capacity to the last drop. I know, also, that the shippers will rally to their support to the full extent of their ability. I know, further that the Office of Defense Transportation will do everything in its power to help them.

The new locomotives and cars which the War Production Board is proposing for the remainder of this year fall far short of what I have believed to be necessary for the successful prosecution of the war effort. The conversations in regard to this matter will continue and I hope that they will eventuate in modified conclusions. I say that, however, with full appreciation of the fact that the Board is confronted with a most difficult situation and that my particular problem, domestic transportation, is only one phase out of many which it must consider. Most sincerely I hope that the Board is right and that I am wrong, and I know that you, as well as I, will do everything that we can do to make them right, if they do not modify their present conclusions.

Your Car At War[1]

By PYKE JOHNSON

President of the Automotive Safety Foundation, Washington, D. C.

• There is a critical shortage in rubber. Stringent limitations have been imposed on the manufacture of motor vehicles. Conservation of vehicles and tires is today's challenge to all motorists. How to meet this challenge is comprehensively outlined by Mr. Johnson in the following discussion.

THIS is my first talk in my new capacity. That it should be made here is doubly pleasant because not alone is yours one of the best organized councils in the country, but it is led by the man who created the Automotive Safety Foundation—Paul G. Hoffman.

So, I feel that I am saying something of personal interest to you when I begin by paying tribute to him for the magnificent contribution which he has made and is continuing to make to the cause of safer and better highway transportation.

Your friend and mine, he is one of those great Americans whose lives are a constant inspiration, and whose deeds record better than any words, their unselfish devotion to the public interest.

Let me add that his relinquishment of the presidency of the Automotive Safety Foundation does not mean that the organization will lose his leadership and counsel. On the contrary, he is needed now more than ever before, in his capacity as Chairman of the Board, to give stimulus and direction to the broad program which the Foundation has undertaken to help meet the new and urgent problems imposed by war.

Not New Problems

Perhaps I should not say *new* problems. The conservation of life through prevention of accidents; the proper care and operation of motor vehicles; the improvement in efficiency of roads and streets—these are not new objectives at all.

Indeed, substantial progress toward their achievement has been made in recent years. The encouragement and backing given to public officials, and the timely recognition of community effort through the awards given here tonight, are evidences of the splendid work of the Indiana Traffic Safety Council, among others, toward these objectives.

Rather, I should emphasize the stark urgency of these problems, and the grim necessities for their solution which the war has generated.

No soft words can be used in describing the position which you and I, and all Americans, face today.

Critical Shortages Face Us

At the very moment when efficient movement of men and materials is most needed, there are critical shortages of facilities, both in roads and in rolling stock.

Our sources of rubber supply have been cut off. Our transportation system is inadequate to meet both our fuel oil and normal gasoline requirements. The creation of a giant war industry has not yet been matched by roads equal to the task of transporting the new armies of labor and tons of products which must move over them.

And, accidents are claiming the lives of productive workers in a period when every casualty is a handicap to that full mobilization of resourcs which is a first prerequisite to victory.

Meeting these conditions will be no easy job for any of us. It can be done. It will be done, of course. But, it will require changes in the ways of living of all of us, and changes that, to be most effective, should begin now.

Must Conserve Resources

We must conserve our resources—to the limit.

If we do not, then not alone may we be left without that individual transportation which is so much a part of our daily lives, but far more important to all of us, the war production program will be seriously affected.

These are not easy things to say, but unfortunately they are all statements which are grounded on solid fact. Let me document them:

1. Passenger car production in the United States was terminated February 10. Assembly lines were uprooted to make way for all-out war production. In consequence, there is no automobile manufacturing industry in the United States today, and Amer-

[1] Presented before Indiana Traffic Safety Council, Indianapolis, April 8, 1942.

ican motorists as a whole are therefore now riding in their last cars for the duration of the war, and possibly for months thereafter.

No More Rubber Available

2. The enemy now controls areas from which more than 95 per cent, not alone of our crude rubber supplies, but those of the United Nations, have originated.

3. The demands for war production for the uses of the military forces of the United Nations have been stepped up to extraordinary figures, and in their production, rubber or its substitutes, are vital.

4. We have at the moment only the small beginnings of a great synthetic industry which it will be necessary to create to meet the demands of this Gargantuan machine.

That we have the "know-how" to build this industry, no one can doubt.

That it will be built and at a rate of speed exceeding any past record, is without question.

Yet, in order to do this job, in order to bring into being the capacity for 700,000 tons annually of synthetic material now visualized as the government war program, the administration must draw upon the stockpiles of materials critically needed for other war purposes, such as sheared plate steel.

That means that cargo ships, battleships and other instruments of war cannot be built as quickly, so it must be evident that under such conditions, only such capacity will be built as is essential for war needs.

That, obviously, does not include synthetic rubber for any tires which may not be absolutely needed.

And so, the conclusion is forced upon us that the crude rubber which is still essential to the construction of tires will not be forthcoming for ordinary uses.

We must husband the life in our present tires to the limit if our motor vehicles are to last out this emergency.

Fuel Depends on Transport

5. In so far as the gasoline situation is concerned, there is no shortage of the fuel itself. The problem rests upon the loss of those tankers in the two oceans which have been a principal means of movement of gasoline in the past; in the sharply increased demand for fuel oil, which is an essential part of the war production problem, as well as a matter of warmth for millions of Americans; and, in the enormous new demands made upon our land facilities as a result of the shift in movement, and in the increase in the war program.

These drastic limitations imposed by the necessities of war, face all of us squarely with a personal transportation problem that cannot but affect, in intimate detail, your lives and mine.

Nation Geared to Highway Transport

Suppose we examine this side of the problem for a moment.

For forty years now, America has been building an economy geared to individual, personal transportation. A few key facts will illustrate the extent of this transition.

Today we have 29,000,000 passenger motor cars in the United States. On the basis of studies made by the Public Roads Administration, in corporation with the several State Highway Departments, these vehicles for necessity use alone, have carried in the past three and one-half times as many billion miles of passenger traffic as all other forms of transportation put together.

As the instruments of mass passenger movement on the highways we have only 141,000 buses. Of these, 93,000 have been used in transporting children to and from schools. They are doing a great job but they can't do it all.

Today, there are more than 45,000 communities in the United States which have no railroad transportation; there are six States which have no streetcars within their borders; there are 18,000,000 people living in rural areas but working in the city, of whom most must travel all the way or a large part of it by automobile in order to get to their work.

War Labor Depends on Cars

And in addition to these sobering facts, it is a matter of common observation that in the decentralization of the war munitions industry, vast new requirements for highway transportation have been created throughout the United States.

Today, there are hundreds upon hundreds of thousands of workers in the war production program who can only get to work by automobiles. Six months from now, we face the dire possibility that there will be serious absenteeism in vital war plants due to tire failures.

Will any American say that this can be allowed to happen?

Under conditions such as these, it must be evident that every possible effort must be made to utilize the great reservoir of transportation facilities which

we have in our far-flung millions of passenger motor vehicles.

We cannot build new units of transportation to meet these essential requirements without dipping into critically needed stockpiles of war materials. We cannot build new housing units without encountering the same problem. We cannot impose unnecessary loads upon the already burdened facilities of other forms of transportation. We must make the most efficient use possible of existing facilities, if we are to carry forward to victory.

Walk When We Can; Share Cars

We must walk when we can; we must reorganize our lives to make a more efficient use of existing transportation facilities; we must share our cars with our neighbors where motor vehicle use is necessary.

These things we must do, first of all, if we are to win the war; second, if as individuals and as families, we are not to find ourselves cut off from all of our present ways of living when our tires fail.

These things done, our supplies may be eked out. Not done, no man can safely say we can escape dire consequences.

How shall we accomplish them? Shall we await government edict, with all of the penalties to the individual that necessarily follow in the wake of regimented control? Or, shall we seek to accomplish these objectives voluntarily, either because we happen to be patriotic Americans, or, if you prefer, because we are awake to our own self-interest?

Country Awake to the Problem

The evidence in all parts of the country is that the public is not waiting; that most individuals and communites are alert to their problems; and that they are beginning to do something about it.

In Michigan, for example, a careful case study has been made in the city of Pontiac to determine the transportation habits of the people.

Then through the cooperation of the Michigan State Highway Department, the public officials of the city, the representatives of the city and parochial schools, the employers, labor, stores, the transportation services, the women's organizations—even the courts—a systematic effort has been undertaken to stagger hours, in order to spread out uses of transportation services; to get people to walk where possible; to get neighborhood clubs under way to provide for joint use of automobiles.

This plan has attracted national attention. Much more will be heard of it as the days go by, yet it is but one of many approaches which are being made to the problem everywhere.

In California, the Automobile Club of Southern California, joined by the California State Automobile Association, the California State Chamber of Commerce, the California Newspaper Publishers Association, Los Angeles Chamber of Commerce, and 300 other state and local fraternal, civic and labor organizations, industrial defense and commercial enterprises, has launched a five-point drive for victory program, directed to the single objective of conserving essential transportation.

In Portland, Oregon, one shipyard has stepped up the average number of passengers carried per automobile from 1.3 to three persons, with the cooperation of the workers themselves.

In western North Carolina, miners have joined in converting light trucks into vehicles capable of carrying ten and fifteen men to work. In other areas, workmen have long been swapping rides, operating "buddy cars," and otherwise doubling up on the use of the automobile in getting to work.

In Washington, D. C., government department hours have been staggered.

In still other cities, women's organizations, working with retail stores, are changing their shopping habits.

So the story goes.

Official Groups Endorse Program

The American Association of State Highway Officials has endorsed a war transportation conservation program. The Office of Defense Transportation has approved it. The Highway Traffic Advisory Committee to the War Department, headed by Thomas H. MacDonald, is now developing, in cooperation with ODT, a program which shortly will be placed before state and local officials.

Many national civic organizations are also interested and working on the problem. The American Automobile Association is urging its members to budget their car mileage among other elements in an extensive program. The National Safety Council is focusing attention upon the "off the job" accident program and related traffic problems growing out of the war. The General Federation of Women's Clubs, the American Legion, the Kiwanis and Rotary clubs, the National Grange and American Farm Bureau Federation, hundreds of other groups are taking up phases of the conservation program as it affects their membership and the American way of life.

Recognizing that these problems were bound to arise, and yet themselves pledged to all-out effort in building guns, tanks, planes and other equipment for the armed forces, the Board of Trustees of the Automotive Safety Foundation, made up of the top-flight executives of the motor vehicle, parts, oil, cement, rubber, and the fiance groups in the automotive industry, voted to expand and reorganize the Automotive Safety Foundation.

Foundation Pledged to Conservation

For the duration, they have dedicated this organization to full cooperation with responsible government officials and national groups with which the Foundation traditionally cooperates, to three major jobs:

1. Conservation of man-power through traffic accident prevention.

2. Conservation of the vehicles and the material going into their maintenance, or use.

3. Development of a sound highway program designed to bring highways up to standards essential to war use and to give men useful employment on the highways, once the war is over.

Consequently, when the government officials charged with conservation of highway transportation called upon the officials of the Foundation for support in enlisting public opinion in this major endeavor, the response was immediate.

We will do all that we can to further this effort.

Indiana Council Focal Point

It is as an ernest of that effort on our part that I am here tonight, not solely, then, to congratulate the men and women of Indiana on their great record of achievement in the field of safety, but to urge you on to new efforts and new responsibilities.

Obviously, like similar organizations in other states, the Indiana Traffic Safety Council is a focal point for the drive to enlist support for state-wide and community-wide programs for the utmost conservation of our limited war transportation resources. Your help is vitally needed.

May I summarize, briefly, the elements involved in this program:

Elements In Conservation Program

1. Voluntary reduction in driving speeds.

2. The need for rigid voluntary limitations upon motor vehicle use.

3. The need for a more careful use of the vehicle in such driving as is essential. Every motor club, every automobile dealer, every service station, every tire dealer, can advise you of ways and means of conserving fuel, tires and vehicle.

4. The need for communal efforts to stagger hours of movement, so that the most efficient use may be made of all forms of transportation.

5. The most intensive accident prevention programs that can be employed for the conservation of life, limb and property in traffic use. We must conserve our factory workers in war production. "Off the job" traffic safety programs, such as that developed at your own city of South Bend, may do much to shorten the war through the saving of every possible man-hour of production.

6. Pooling of car use to the fullest extent possible.

7. Release of scrap rubber for war purposes.

8. Dedication of highway funds to roads vitally needed for war transportation.

Traffic Hazards Increased

Traffic hazards naturally may be expected to decrease in terms of normal exposure. The war emergency, however, has injected new and dangerous elements, such as operate under air raids and blackouts, interference with emergency military movements, increasing age of vehicles, with resultant dangerous wear on vital parts and an increase in the nervous tension and war psychology of drivers.

Cessation of production of new passenger automobiles and light trucks means that vehicles in use will be driven longer. Roads, buses and trucks will be called upon for greater service. Tires will be used to maximum mileage and replacements will be increasingly difficult. Loss of service station manpower may affect maintenance standards, and the frequency of inspections. New demands on police and traffic engineering personnel, and the shift of experienced men from these to other fields are factors which cannot be overlooked. Nor can diminishing registrations automatically solve the traffic accident and traffic control problem.

Britain's Fatalities Increased by War

Experience in Great Britain proved that from 1938 to 1941 vehicle registrations dropped by two-thirds, while traffic fatalities, on the other hand, rose from 6,000 to more than 10,000 in the same period.

Our own nation experienced a further increase of 6 per cent in January 1942 traffic fatalities. A decrease of 8 per cent in February from the total of the same month in 1941, may be a reflection of fewer car miles, but National Safety Council officials warn against any feeling of complacency.

(Continued on page 22)

Effective Use of the Assignment Procedure in Marketing Agstone

By P. E. HEIM

Sales Manager,
The Carbon Limestone Company,
Youngstown, Ohio

• When the AAA began the purchase of agricultural limestone under the Grant-of-Aid Program, many new and difficult problems were created for the commercial producer. Some of these have been successfully solved through use of the assignment procedure. How it works and its advantages are helpfully described by Mr. Heim.

IN THE beginning of the Agricultural Conservation Program the farmers bought their own limestone and received a check from the Government at the end of the year. In 1940, in our marketing area, the materials program was started, whereby a farmer was given limestone in lieu of a check. It was in this year that we first took assignments.

The procedure of handling assignments was entirely new to us; so we worked it out by the trial and error method. About ninety percent of the assignments were made directly to us and the balance handled by our dealers. All but ten of these were on the basis of ninety percent of the amount that the participating farmer could earn. Our reason for taking them this way was that a farmer quite often changes his mind at planting time and plants more acres than he anticipated when his farm plan was made out during the winter. By our not taking the assignments for the full amount, we found that the ten percent took care of unexpected changes, and did not necessitate our having to call on the farmer to collect a small balance. In cases where the assignment did not pay out in full, it was hard to explain to the farmer, because he was of the impression that the County Committee said "he would not have to pay any more."

In Pennsylvania we handled the assignments on the ninety percent basis, but in Ohio on a seventy percent basis. The reason for the lower percentage in Ohio is that we are located in a section where market gardening is prevalent. This type of farmer can over plant his acreage easily and thereby reduce very rapidly his expected payment.

Out of about three hundred assignments in 1940, sixteen of the checks were insufficient. The deficiencies ranged from ten cents to ten dollars and twenty-one cents. Ten of the sixteen were on assignments that were made on the basis of 100 percent of the anticipated earnings. Shortly after these assignments were made there was a general reduction of ten percent of the money allotted to the counties, thus causing the deficiencies in these checks. It took several letters and, in many cases, a personal call to collect these balances. In some instances a second call was necessary before the farmer could be found at home or he could be convinced that he still owed us money.

The first checks that we received on the 1940 assignments were in November, with most of them coming in January and February. It was about the middle of April before all of the checks were received. The delayed payment on assignments makes it difficult for small companies to handle very many of them.

In 1941 we had assignments from about six hundred farmers. We received our first checks in October, which was about a month earlier than the year before. At the end of January, 1942, fifty percent of our checks had been received and of these, only one failed to settle in full.

Our agricultural limestone is all marketed through dealers. We found that many small dealers do not have sufficient capital to carry very many assignments. There are others who are not too responsible financially; and some that do not pay their bills when they do receive their money from the Government. Because of these factors we had all assignments made in favor of our company this past year, and this worked out very satisfactorily.

We found that it was preferable to have the assignments executed in the county office rather than in the field, because the office has complete information concerning the farmer's past record of compliance. The personnel of the county office is better informed and there is less misunderstanding. At the time an assignment was made, a copy was also made on a form which we furnished. On this was shown our company name, the name and address of the farmer, the number of tons of limestone, the amount in dollars, and the dealer's name. This form was given to the farmer, who presented it to our dealer, who in

turn delivered the material. The dealer turned the form in to us for credit at the time of settlement.

In the beginning we did not charge any interest on assignments. Because the farmer making an assignment paid the same as a cash customer, our business rapidly went to assignments. This was changed in 1941 and we charged six percent interest for a period from the date the assignment was signed by the farmer to the end of the Conservation year, which was September 30th. This of course did not compensate us for the full time we had to wait for our money, but it did in part, and it kept the cash buyers from making assignments.

In 1940 the assignments included the material and the trucking charge. The following year the amount earned by the farmer for using one ton of limestone was reduced, and necessitated our taking the assignments on a plant price basis, with the farmer paying the trucking charge to the dealer. This was a more satisfactory arrangement for us, because we did not have so much money involved. It was also good for the farmers because they could get more tons of material; and this they did. The farmer who had a little money invested in his limestone really made good use of it and did not have to be urged by his community committeeman to get it spread.

Assignments were not used by us as a matter of choice, but as a means of remaining in the business in a territory in which we have marketed our product for over twenty-five years. We are fortunate that our plant is located in a limestone-consuming territory, but are unfortunate in that we market in two Soil Conservation regions that have different specifications for materials. The large part of our tonnage is a product known as Ground Limestone, which has 100% passing a 10 mesh sieve, 90% passing 20 mesh, 55% passing 60 mesh and 50% passing 100 mesh. This is kiln dried and sold in bulk. It is a little too coarse to meet the specifications in the Northeast Region and too fine to meet the price competition in the North Central Region. We hesitate to change our specifications because this grade is well established with the farmers in our section; also there is nothing to indicate that the present specifications of the Conservation Regions will be permanent.

One objection to assignments is the delay in payment. There are some banks that will discount them, provided they are secured by a note. If this can be done, then this objection is not so serious. Having an assignment is no guarantee that you will get your money unless the farmer fully complies with the program. One of the requirements is that the limestone must be spread. When this is not done, no payment is earned. The manufacturer and the dealer can perform their parts of the agreement, but if the farmer does not do all that he is required to do, the assignment will not be paid or perhaps only in part.

In my judgment it is more satisfactory to sell limestone on the materials program if you can, because you will get your money quicker and be paid in full for the tonnage furnished, regardless of whether the farmer carries out his practices 100 percent. When this is impossible, the alternative would be the use of assignments.

A Method for Proportioning Concrete

(*Continued from page 10*)

Conclusion

The present method of concrete proportioning is based on the results of laboratory tests. Its application will produce workable concrete of the desired strength and durability. By a very simple procedure, coarse aggregates of any size, shape or specific gravity and fine aggregates of any gradation and specific gravity are used in the correct proportions. The influence of mixing water on strength and durability is not ignored, but is recognized in a practical and reasonable manner.

Appendix I

Explanation of why b/b_o = dry, rodded volume of coarse aggregate in a cubic foot of concrete.

Let b_o = solid volume of coarse aggregate in a cubic foot of coarse aggregate.

Let b = solid volume of coarse aggregate in a cubic foot of concrete.

Assume two cubic foot measures, one filled with concrete, the other with dry, rodded stone.

Assume the cement, sand and water are removed from the concrete, leaving only the coarse aggregate. Let its volume, in a dry, rodded condition equal V. By definition, its solid volume = b.

Then V = the solid material plus the voids = b + pV where p equals the percentage of voids in the dry, rodded stone,

or $b = V(1 - p)$ ---------- (1)

The cubic foot of dry, rodded stone is composed of the solid volume of the stone (b_o) + the voids, so

$1 = b_o + p \times 1$, or $b_o = 1\ (1 - p)$ ---------- (2)

From equations (1) and (2):

$$b/b_o = \frac{V(1-p)}{(1-p)} = V = \text{the dry, rodded volume of stone in a cubic foot of concrete.}$$

The Origin of Aggregates[1]

By HAROLD S. SWEET
Research Engineer,
Joint Highway Research Project,
Indiana State Highway Commission and
Purdue University

THE suitability of various aggregate types for use in highways is a question that frequently confronts engineers. To solve this problem many tests have been devised for determining the road making properties of aggregates. A knowledge of the geological origin, composition, and method of formation of the various rock types will enable a better understanding of the highway performance of these aggregates.

The naturally occurring mineral aggregates of Indiana may be divided into several groups: Crushed limestone, predominantly from quarries in the Silurian, Devonian, and Mississippian systems; gravels of glacial or glaciofluvial origin; river gravels; residual gravels; and so-called "tertiary gravels." The first three of these groups are more important for materials in higher type roads, but residual gravels and tertiary gravels have considerable use in secondary roads. Represented in these aggregates are igneous, sedimentary, and metamorphic rocks, the three great classifications based on mode of formation.

The igneous rocks are those rocks that have been formed from the solidification of molten matter that originated within the Earth. They are termed primary rocks since all other types are derived from them. There are many subdivisions of this class based on mineral composition and size of crystals. The more important igneous rocks are basalts (trap rocks) and granites. They are desirable aggregates since they are usually sound, tough, and resistant to abrasion.

Under the action of weathering and erosion, igneous rocks are broken down, transported by streams, and the fragments are deposited in lakes and seas. These deposited sediments form sedimentary rocks. The bedrock outcrops in Indiana are all of this class. They include limestone, shale, sandstone, conglomerate, and chert. All of the sedimentary rocks have wide variations in their properties and in their suitability as aggregate. Many limestones are excellent roadbuilding materials.

[1] Reprinted from "Highway Hints," Indiana State Highway Department.

The third class, the metamorphic rocks, is derived from the first two groups. Due to heat or pressure, or both, the igneous and sedimentary rocks may be changed in structure or mineral composition to form different rock types. Under metamorphism, limestone changes to marble; sandstone changes to quartzite; shale changes to slate, or if the metamorphism is extreme it changes to mica-schist. Granites and other igneous rocks are frequently transformed into gneisses. Metamorphic rocks are usually durable with the exception of mica-schists. These, because of their foliated structure, are susceptible to splitting.

The glacial and glaciofluvial gravel deposits frequently contain a large amount of limestone and marble, and smaller amounts of granite, traprock, sandstone, quartzite, chert, slate, shale, and ocher. The amount of chert, quartzite and igneous rock is higher in the river gravels. The residual gravels found in creek bottoms of the unglaciated portion of the state consist of fragments of the bedrock which is underneath. These fragments are usually pieces of shale, iron concretions, chert, and quartz concretions. The tertiary gravels are the remnants of very old river channels which have now been abandoned. Present drainage has eroded the land surface so that these old river beds are now two hundred feet or more above the existing creeks. The gravels are quite widespread in southern Indiana and consist of chert, quartz geodes, and quartzite.

The Joint Highway Research Project is studying the roadbuilding properties of aggregates in order to establish more definitely the relationship between geological origin, mineralogical composition, physical properties, and field performance of the various aggregate types.

WIDESPREAD concern over loss of state revenues as a result of war-time restrictions on highway transportation is reflected in S. 2580 by Senators Russell (D., Ga.) and Maybank (D., S. Car.) to reimburse states for losses from gasoline tax revenues resulting from gasoline rationing.

The bill would require the Secretary of the Treasury upon determination of the amount of loss from gasoline taxes, to reimburse rationed states for such loss as soon as practicable after the end of each calendar quarter.

Your Car at War

(Continued from page 18)

The Problem After the War

It may seem idle to discuss post-war problems when our single objective now is to win the war and win it as quickly as possible.

But after all, the American people have objectives in fighting this war, and one of them surely is that when it is over, the men who have fought it shall not starve, nor shall they be brought back to subsist on doles.

There must be employment for them—useful employment with all the opportunity for advancement that has made America what it is. It is not enough to create jobs. The work itself must add to our capital facilities.

One of the largest fields for that employment will be found in the need which will exist for a great national highway development designed to provide the way for safe and efficient highway transportation.

If the war lasts any length of time, we will have even greater deficits in our highways than exist today and in our vehicles. Both will not only have to be replaced, but replaced in the light of changed conditions.

Today, every penny of highway expenditure must be dedicated to those roads which are essential to the war effort, and even then, they probably will fall short of maximum requirements.

Prepare Now for Post-War

But, if we are to be ready with a program based on safety and traffic needs when the war is over, then we must have master plans ready for highway improvement, carried forward to the blueprint stage, and growing out of factual studies of transportation habits such as are contained in the state highway planning surveys.

We must have changed those laws which stand in the way of quick acquisition of rights of way where needed in the public interest.

We must be sure that competent highway engineering organizations, such as we have in the PRA and states today, are available to carry forward the work.

We must be sure that every penny of the revenues which will accrue from highway use, are allocated equitably for maximum return.

These are large projects of fundamental importance to the future of America, on which spade work must be done now if we are to be ready to apply them when peace and sanity return to the world.

All these undertakings are of immediate importance to the people of Indiana, as well as of the United States.

Fit Into Pattern of Indiana Program

They fit exactly into the pattern of your program. They require the type of understanding and intelligence which your background gives. They must be given popular support to their full accomplishment. In essence they are a true and vital expression of democracy at work.

As the representative of those great highway transportation industries which today are dedicating their full effort to war production, I pledge you our full support in whatever you may be able to do to help yourselves and America in these fundamental programs.

Federal-Aid Highways Completed This Fiscal Year Total 6,368 Miles

DESPITE war-time restrictions, 6,368 miles of Federal-Aid highway projects had been completed during the current fiscal year on May 31. These projects cost $188,253,089 of which $99,192,324 was Federal-Aid. These figures are carried in reports of the Public Roads Administration.

There are 5,439 miles of Federal-Aid highway projects now under construction, estimated to cost $201,-678,594 of which $113,540,681 is Federal-Aid. Approved for construction are 979 miles of Federal-Aid highways, expected to cost $40,682,688 with Federal-Aid supplying $23,758,315. Balance of funds available for programmed projects in all the states, the District of Columbia, Hawaii and Puerto Rico, totals $135,919,182.

On May 31, 188 highway-railroad grade crossings were eliminated by separation or relocation; 59 grade crossing structures were reconstructed; and 518 grade crossings were protected by signals or otherwise during the current fiscal year. Grade crossing projects now under construction total 379, while 276 such projects have been approved for construction. Estimated cost of completed projects totals $25,187,300, while those under construction are expected to cost $34,477,607 and cost of projects approved for construction is estimated at $8,698,521. There was a balance of $46,280,921 available for programmed grade crossing projects.

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